#99-06 (Nov-Dec 99)

EUROGRAM

EUROPEAN OFFICE OF AEROSPACE RESEARCH AND DEVELOPMENT

CC HIGHLIGHTS

EOARD, AFOSR and AFRL just completed one of our best-ever years of international efforts. In addition to the Russian Initiatives in directed energy and hypersonics highlighted in the last Eurogram, EOARD completed a record number of Window on Science visits (294), conferences supported (81), and special contracts awarded (110) in fiscal year 1999. Continuous process improvement and automation have aided our success, but it really gets down to good old hard work by our program managers and support staff. Special kudos go to our folks in Contracting (Mrs. Candy Lindsly), Finance (Mrs. Barbara Murphy and Mr. Chuck Short), Window on Science Support Services (Mrs. Stephanie Brewis), and Database Support (Mr. Nigel Jones and Dr. Barry McKinney). Thanks to all for a stupendous year! And as always, please contact us with your suggestions for improvements.

We've changed the titles of our technical staff from Liaison Officers to Program Managers to more accurately reflect their duties, and to more closely align ourselves with AFOSR practice. The folks are still pretty much the same hard-chargers, though we'll say goodbye to Dr. Barry McKinney, Chief of C4I and IT, in December. Barry and family are leaving us to return to the Information Directorate in Rome NY. Barry, you will be missed!

Double congratulations to Major Tim Lawrence, who swam the English Channel (Dover to Calais) 4 September and pinned on his new rank 1 October. See the complete story on http://intra.afrl.af.mil/news/index.htm

EOARD sponsored Prof. Dr. Valentin I. Vlad, Member of the Romanian Academy, Institute of Atomic Physics & Bucharest University to consult with scientists in the USA. Though a Fellow since 1978, Prof. Dr. Vlad had never previously attended an Optical Society of America Annual Meeting. His report may be found on page 9.

For the Commander
Robert S. Fredell, Lt Col, USAF, Technical Director

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PROGRAM MANAGER REPORTS

Lt Col Robert S. Fredell
Technical Director

Site Visit: Dowty Aerospace Propellers, Gloucester, United Kingdom, 14 September 99. The primary host and POC was Mr. Tom Brown. This visit, with the survivability group formerly of AFRL/VA, was a first step in arranging live-fire testing of one of the major improvements made on the C-130J model, the carbon fiber/epoxy propeller blades. They represent major advancement in the state of the art for a complex three-dimensional composite structure. The blades are a foam core overlaid with dry unidirectional carbon fibers overwoven with a continuous "knit sock" of bias-ply carbon and glass fibers. The assembly is then injection-molded with an epoxy matrix and non-structural inserts are adhesively bonded. Several protective coatings are then added. Live-fire testing of the blades is planned for the coming year at Wright-Patterson AFB. Live-fire testing of the blades is planned for the coming year at Wright-Patterson AFB. For more information on the blades, contact Catherine Wain, Senior Structural Engineer, Dowty Aerospace Propellers, tel +44 1452-716-071. For more information on the test, contact Alex Kurtz, 46 TW, Wright-Patterson AFB OH.

Site Visit: Engineer and Scientist Exchange Program (ESEP) quarterly meeting, Munich, Germany, 19 – 25 September 99. The primary hosts were Captains Paul Blue +49 8153-28-1181 and Cindy Klahn +49 8459-802-578.

This regularly scheduled review of the ESEP program included presentations from the seven current exchange engineers (4 stationed in Germany, 2 in France, 1 in Australia). Tours of the following German facilities were also included Daimler-Chrysler Aerospace in Ottobrunn and Manching, WTD-61, the German military Flight Test and Airworthiness Center in Manching, the German Military Research Institute for Materials (WIWEB) in Erding, and the German Aerospace Research Center (DLR) at Oberpfaffenhofen, including the Institute of Robotics and System Dynamics, the German Space Operations Center, and the Remote Sensing Data Center. The new ESEP group for the 2000-2002 exchange is being finalized at AFOSR. ESEP is open to non-supervisory USAF civilian and military research engineers and scientists. For more information, contact Mr. John McMann at 703-696-7324 or John.Mcmann@afosr.af.mil

Site Visit: Air Force Chief Scientist's review of command and control in the United States Air Forces in Europe (USAFE), England, 21 – 25 October 99. EOARD and the Research and Development Liaison Office-London hosted Dr. Lou Metzger (AF/ST) and Col Don Erbschloe (former EOARD Chief Scientist), and escorted them on their visits to the UK Ministry of Defence, London, the Joint Analysis Center, RAF Molesworth, the 100 Air Refueling Wing, RAF Mildenhall, and the 48 Fighter Wing, RAF Lakenheath.

Conference: "Advanced Materials 1999", Kiev, Ukraine, 2 – 8 October 99. The primary host and POC was Professor Sergiy Firstov, Institute for Problems of Materials Science (IPMS). The IPMS was founded in 1955 and is now headed by academician V. Trefilov, a prominent researcher in deformation, fracture mechanics and ceramics technology. The staff includes 80 Professors and about 400 Ph.D. candidates. The research interests range from metallurgical and ceramic processing to solid state physics of narrow-band gap semiconductors. In the former Soviet Union, the IPMS was the leading institute in powder metallurgy.

A follow-up to a tri-service visit to Kiev in May 1999, this visit was made in conjunction with the EOARD co-sponsored Conference on Advanced Materials 1999. After an overview by the director and Prof. Sergiy Firstov, I toured the laboratories and received briefings from the technical staff. IPMS runs a range of research efforts including:

- in-situ titanium matrix composites (eutectic Ti-Si composites) with extremely high specific mechanical properties up to 800^{o}C,

- electrochemically "foamed" open-cell Ni, Ni-Cr, ceramic, and Ni-coated ceramic porous structures,
- superhard and ceramic materials for wear- and heat-resistant devices,
- Al-Sc alloy development, and
- basalt fibers to replace asbestos for low-cost insulation materials,

The IPMS is currently executing an "In-situ Eutectic High-temperature Ti-based Composites" contract for EOARD and AFRL/ML. It involves an investigation of cast Ti-Si-X and Ti-B-X eutectic alloys, including structure and physico-mechanical properties (strength, fracture toughness, long-term high-temperature hardness etc) in a range from room temperature up to 1000°C. The first deliverable has been received; if interested, please contact Dr. Dan Miracle at Daniel.Miracle@ml.afrl.af.mil for a copy.

The quality of research at the IPMS appears to be extremely high. IPMS scientists are eager for collaborations with the US and Western Europe, and they have much to offer in terms of different approaches to scientific problems. I join my Office of Naval Research counterparts in urging DoD materials scientists and engineers to develop collaborations with their Ukrainian counterparts where practical.

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For a more extensive overview of IPMS and materials science activities in Ukraine, see http://www.ehis.navy.mil/onrnews.htm#wilcox
Report 99-007: Joint Materials Science and Engineering Newsletter - Report on: Materials Research in some Ukrainian Institutions (Kiev), by J. Christodoulu, I. Vodyanoy and B. Wilcox of the Office of Naval Research (Europe).

Major Jerry J. Sellers
Astronautics

Conference: 14th Int'l Symposium on Air-Breathing Engines, Firenza (Florence), Italy, 4 – 11 September 99. The primary host and POC was Professor Frances Martelli. EOARD helped to sponsor this semi-annual symposium, the largest meeting of its kind focused on research and development issues of jet and combined-cycle engines. Over 500 participants from dozens fo countries including a large contingent of AFRL and NASA researchers attended the symposium. Nearly 50 technical sessions included 300 individual papers. Topics included: combustors and combustion issues; heat transfer and cooling; computational fluid dynamics applications; creep, failure and other material and mechanical issues; gas turbine issues, simulation and testing; endothermic fuels; hypersonic propulsion; pulsed-detonation combustion; and combined-cycle propulsion.

Highlights of the conference included:
- reports on JAPHAR, a joint German/French initiative in hypersonic propulsion based at each country's leading aerodynamic research sites, ONERA in France and DLR in Germany.
- NASA, Boeing-Rocketdyne and Aerojet presented recent developments in rocket-based combined-cycle propulsion.
- French researchers from ONERA presented experimental and numerical analysis of turbulent flow inside ducted rocket inlet.

For a complete list of presented papers or information on the conference please contact

Major Jerry Sellers, Dr. Charbel Raffoul or Mr. Peter Ouzts.

Meeting: US Embassy, Rome, Italy, 16 September 99. Major Ed O'Connell, assistant air attaché, hosted this meeting held to brief the attaché office on EOARD's mission and on-going activities in Italy. Major O'Connell was enthusiastic about the prospects for expanding contacts in science & technology and highlighted the interest within his office to broaden ties between US and Italy. Discussion focused on Italian activities in space including plans to reactivate the San Marco launch facilities (off the coast of Africa) using converted Ukrainian SS-19 ICBMs (currently marketed as the "START" launch vehicle). The San Marco facility was used to launch the US-made Scout launch vehicle but this vehicle was discontinued in the early 90's. Researchers at the University of Rome are currently building a small satellite planned from launch on the refurbished facility. Major O'Connell and I agreed to continue to coordinate on both US/Italy R&D efforts involving AFRL areas of interest.

Conference: EOS/SPIE Remote Sensing Conf., Florence, Italy, 19 – 25 September 99. This meeting was jointly sponsored by the European Optical Society (EOS) and the International Society of Optical Engineers (SPIE). The Symposium featured nearly 300 technical papers presented in 10 separate parallel sessions covering the following topics:

- Laser radar techniques (ranging & atmospheric Lidar)
- Optics in atmospheric propagation & adaptive systems
- Remote sensing of clouds and atmosphere
- Remote sensing of the ocean and sea ice
- SAR image analysis, modeling and techniques
- Remote sensing for earth science applications
- Image and signal processing for remote sensing
- Photonics for space & enhanced radiation environments
- Commercial remote sensing platforms & applications
- Sensors, systems and next generation satellites

I focused on "Sensors, systems and next generation satellites." This series included 60 papers covering the areas of: Future satellite programs, Sensing technologies, Hyperspectral sensing, and Sensor calibration. Highlights included:

- An overview of the SkyMed/Cosmo project. This Italian government effort is aimed at short-revisit time, regional-scale remote sensing. The plan is to provide 2.5 m panchromatic along with hyperspectral images using a dual band thermal imager in a pushbroom configuration. The sensor arrangement is expected to be especially useful for coastal zones and land management as well as risk monitoring and environmental study. A constellation of 7 satellites would allow for only a few days between revisits.
- A study by Alenia Aerospazio (Italy) proposing to apply SAR processing techniques to radar altimetry for enhanced resolution.
- Dr. Tony Ratkowski, AFRL/DE, presented work including contributions from Dr. Adam Devir, Institute of Advanced Research & Development, Israel on atmospheric transmission measurements as compared to MODTRANS (standard atmospheric IR/vis/UV transmittance, radiance and flux model). The work with Dr. Devir was completed under an EOARD contract. We are currently considering proposals for follow-on activities.
- V.I. Vavilov Space Optics Institute, Russia, presented work on a solar flare monitoring project supported by ISTC in collaboration with French and German partners.
- The Israeli firm El-Op Electro-Optics Industries, Ltd. presented camera development work for the EROS commercial remote sensing constellation (planned first launch early 2000). This will be ~250-kg minisatellite initially providing approximately 1-m class panchromatic resolution. Follow-on satellites will include 3-channel multispectral sensors. One versions will provide

panchromatic images with a 12.5-km swath. A second version will provide multispectral images with a 16.4-km swath.

Overall, the conference demonstrated that there are a wide variety of international activities in remote sensing. Very high resolution (<2.5 m) panchromatic imagery is practically becoming an “off-the-shelf” technology. Both multispectral and hyperspectral imagery for government and commercial applications is rapidly becoming common place. For more information on the Symposium visit (http://www.europto.org/meetings/ers99/home.html) or contact Major Jerry Sellers.

Conference: International Astronautics Federation, Amsterdam, Netherlands, 3 – 9 October 99. The UK Defense Evaluation & Research Agency (DERA) spoke on their Space Technology Research Vehicle (STRV) satellites. STRV 1a & 1b have provided them with a wealth of data on high-radiation space environments. Operating in geo-synchronous transfer orbit, these spacecraft receive the equivalent of 9 years total dose for a low-Earth orbit satellite in only 12 months. The next STRV missions, 1c & 1d will test CCSDS packet communication protocols in secure mode, among other technologies. DERA would like to see their STRV platform used as a test-bed for future small interplanetary missions.

The French Space Agency (CNES) presented progress on their small satellite program, a “kit" approach for rapid, low-cost missions with CNES acting as the prime contractor. Two missions per year are planned each costing about FF 50M ($8M US) and including payloads of 30-40 kg, 30-40W. CNES is also implementing a dedicated program to allow for international cooperation on these missions, including training in spacecraft design and project management. The spacecraft will be 3-axis stabilized with 2 sun-tracking arrays and 9 Ahr lithium-ion batteries and a hydrazine monopropellant propulsion system. Additionally, CNES sponsors on-going research and development into new subsystems including new computers and X-band communications. The first launch for the new small satellite series is planned for 2002. Planned payloads include DEMETER, to measure ionospheric perturbations and correlate them to seismic activity, and PICARD, to take solar observations and relate sunspot number vs. semi-diameter variation. Brazil, a payload partner, will provide some system integration and launch.

The Italian space agency (ASI) presented information on their multi-mission satellite bus designs, PRIMA and MITA. PRIMA (Reusable Italian platform multiple application) is a 300-1000 kg bus featuring 3 axis stabilization. MITA (Italian advanced technology minisatellite) is a 100-kg, 70 W bus featuring high efficiency cells plus field effect electric propulsion (FEEP). Two missions selected for these new bus designs are AGILE, a $27M mission to fly a gamma ray telescope (2000) and DAVID, a $36M mission to research high frequency telecommunications varying transmitter power to adjust for weather at the receiver site. ASI plans for a launch every one to two years, and they are currently reviewing the call for proposals for the next round of missions. For a list of papers accepted for the IAF congress visit (http://www.iafastro.com/) or contact Major Jerry Sellers for more information.

Site Visit: Central Institute for Machine Building (TsNIIMASH), Moscow, Russia, 10 – 15 October 99. The primary host and POC was Dr. George Karabadzhak. This meeting was to review Dr. Plastin’s on-going work on rocket plume modeling sponsored by EOARD. Dr. Plastin and his team will present a week-long seminar on the computer software they have developed to model plume radiation at the Arnold Engineering Development Center (AEDC), TN 1-5 November 1999. Previously, the team presented the portion of the code used to analyze solid rocket motor plumes. The second and final version is used to model liquid rocket engine plumes, including the effect of soot in the exhaust products. We discussed possible follow-on work to this project including the addition of non-equilibrium NOx bands to the model and other improvements.

We also met with Dr. Sergey Tverdokhlobov to discuss EOARD-sponsored work on low-power Hall Effect thrusters. The electric propulsion (EP) group at TsNIIMASH first began work in EP in 1959 and their experience includes Hall, ion, magneto-plasma dynamic and pulsed plasma thrusters. Their Hall effect thruster work has focused on their unique TAL (thruster with an anode layer) design. Previous applications of Hall effect technology have been at relatively high power levels (>1 kW). AFRL is interested in low-power (< 200W) for future small satellite applications. Under their current contract, TsNIIMASH is collecting experimental data on TAL performance under these operating conditions. I received a tour of the EP lab and witnessed a live fire test that is part of the EOARD contract. During the test, one of the TsNIIMASH TAL engines was throttled over the range of 200 – 120W while I observed the firing within the vacuum chamber and reviewed their test procedures.

Site Visit: Research Institute for Precision Instrument Engineering (IPIE), Moscow, Russia, 12 October 1999. Prof. Victor Shargorodsky, Head of the IPIE, hosted this meeting to review the current status of on-going contract with RISDE to look at applications of their retro-reflector technology to small, in-orbit test platforms. The REFLECTOR project involves research into a small, 8 kilogram calibration satellite (More details can be found in the Sep-Oct 98 Eurogram). The majority of work has been completed on the project and RISDE is awaiting launch with the Russian Meteor-3 spacecraft currently scheduled for June 2000. We also discussed follow-on work to this contract including creation of a website to document mechanical details of the instrument for potential users and coordinate applications and results. In addition, we discussed another AFRL-funded effort to investigate imaging characteristics of deep space objects. This project has interesting applications for space debris monitoring and related research.

Site Visit: Khrunichev State Research and Production Space Center, Moscow, Russia, 13 October 1999. The meeting was organized by Guy Spitale (AFRL/DE) and hosted by Dr. Stan Veniaminov, leading scientist, Kosmos scientific research center, and Dr. Eugene Nikishin, chief specialist Khrunichev. Khrunichev includes the KP Salyut organization, a primary producer of Russian space hardware. The AFRL/DE satellite assessment center is interested in research into spacecraft survivability and surface photometry including the long-term effects on spacecraft materials exposed to the space environment, their mechanical, thermal, optical and electromagnetic properties (secondary electron emission and charging).

Khrunichev representatives have a long history of space material testing including numerous samples flown and tested on MIR and previous space stations. Their experience clearly rivals the NASA long duration exposure facility (LDEF). The Russians highlighted the uncertain fate of MIR and the potentially large cost associated with mounting a dedicated mission to remove existing materials. Therefore, the most likely way to gain access to MIR materials would be to take samples from the thermal blanket and other materials already removed from MIR and currently in storage at Khrunichev. Dr. Spitale expressed his keen interest in this option and explained that the USAF would like to coordinate selecting specific samples and having them tested at the Karpov Institute of Physical Chemistry in Obnisk. Karpov, Russian leaders in space material testing, is currently working under a separate EOARD contract to provide data on a variety of other space materials. Dr. Spitale agreed to coordinate options for a future contract with Khrunichev/Karpov and will return to Moscow in November 1999 for further discussions.

Site Visit: AA Baikov Institute of Metallurgy, Russian Academy of Sciences, 13 October 99. The visit was hosted by Dr. Nadezhda Kiselyova, who demonstrated software developed partly under EOARD contract - Dr. Steve LeClair, WL/MLLM. It uses a neural network-based approach to comb through a massive database material phase relationships. The work uses the database of properties to feed a neural network algorithm to generate predictions of properties of new materials, thus reducing the number that actually need to be synthesized and tested for various semiconductor and EO applications. Cataloging their database of material properties has been the focus of a separate effort at the Institute. So far, they have published the first two volumes of the Handbook of Phase Diagrams of binary metallic systems. These volumes are in Russian but they expressed a strong desire to receive support to publish in English, possibly in electronic format. The main focus of our discussions was on a follow-on EOARD contract Dr. Kiselyova will begin in FY 00 titled "Search for Efficient Methods of Prediction of Multicomponent Inorganic Compounds."

Site Visit: Karpov Institute of Physical Chemistry, Obninsk, Kaluga Region, Russia, 14 October 1999. Dr. Guy Spitale (AFRL/DE) accompanied me on the visit to Obninsk, approximately 100 km south of Moscow. Prof. V. Plotnikov, Director of the Institute, hosted the meeting. Most research is aimed at radiopharmaceuticals used in various diagnostic procedures. In addition, The institute is conducting research into neutron-transport-doped silicon and foamed polyethylene used for filters in the radiochemistry industry.

Established in 1959, the institute currently works extensively with the US DOE and national labs as part of an international effort to provide physical control of fissionable materials. In addition, the Karpov Institute was/is the lead Soviet/Russian research center for space environmental effects on materials. The focus of our discussion was on the current status of two on-going AFRL-funded contracts. The first contract draws upon years of Karpov test data compiled on 1000's of material. Under this effort, the data is being compiled, correlated and converted to MS Access database format for easy comparison with comparable US data. Under the second contract, they are investigating material-testing procedures with an aim toward standardizing methods also of interest to international standards organizations. We also discussed the possibility of Karpov Institute performing some testing and characterization of MIR space station materials that will be provided by Khunichev (see Site Visit this section). Karpov stands ready to complete this testing and has a long history of such material characterization. Dr. Spitale plans to visit Karpov again in November 1999 for further discussions on this issue, which should lead to an EOARD administered contract.

Dr. Barry McKinney
Information Technology and C4I

Site Visit: Faculty of Electrical Engineering and Informatics, Technical University of Budapest, 27-28 September 1999. http://www.mit.bme.hu/eng/.
Dean László Pap hosted the visit in conjunction with Prof. Peceli from the Department of Measurement and Information Systems. They presented the department's research in chaotic dynamics in signal processing, communications security for wireless systems, transient management in reconfigurable control systems, and formal methods for system verification and optimization. The department is supported by DARPA/ITO, GE, Nokia, as well member laboratories of the EU and is also working closely with Stanford and Vanderbilt Universities in the

United States, as well universities in Spain, Ireland and Brazil.

Prof. Habil Andras Lorincz also presented the research interests of his group, the Department of Information Systems at Eotvos Lorand University, Budapest. Prof. Lorincz outlined several novel initiatives in artificial intelligence. His research, having a very pronounced “bio” flavor, is based on understanding how the human information system works. Projects include: brain modeling, neurobiology, and psychophysics. These novel initiatives have contributed to his more traditional efforts in adaptive and autonomous agents, agent systems, and controls. More information can be found at http://www.inf.elte.hu/~lorincz/.

Site Visit: The Gerstner Laboratory for Intelligent Decision Making and Control, The Department of Cybernetics, Czech Technical University, Prague, 29 September – 1 October 99. http://cyber.felk.cvut.cz/gerstner/. POC, Prof. Vladimir Marik, marik@labe.felk.cvut.cz.

Research activities at the Gerstner Laboratory focus on the design and development of knowledge-based systems exploiting advanced AI methods such as distributed/ parallel computing, knowledge acquisition, knowledge representation, machine learning, intelligent planning, and inductive logic programming. Recently, attention has been given to the problems of multi-agent systems and intelligent data-warehouses. Multi-Agent Systems, a distinctive sub-area of distributed artificial intelligence, investigates the behavior of a collection of autonomous agents tasked to solve a given shared problem. It is very often the case that agents in a multi-agent system are pre-existing, heterogeneous entities solving a particular subpart of the global task that would otherwise be beyond their individual capabilities.

Of particular interest was the demonstration of an in-house multi-agent software system for project-driven production planning called ProPlanT. The group substituted classical planning and scheduling mechanisms with the process of negotiation, job delegation and task decomposition within a community of autonomous agents where each represents production or information unit of the modeled factory or process. EOARD hopes to sponsor part of the group on a Window-on-Science visit to AFRL to present their current research and to discuss the possibility of adapting the capabilities of ProPlanT to support information systems and processes.

Another very interesting demonstration was the Application of Projective Reconstruction given by Prof. Vaclav Hlavac from the Center for Machine Perception. Prof. Hlavac’s team has developed an image reconstruction technique that is capable of generating a digital 3-dimensional scene using non-calibrated individual images. For additional information see http://cmp.felk.cvut.cz/.

Site Visit: The Department Systèmes Physiques pour l'Environnement University of Corsica, Corte, France, 18-20 October 99. Prof. Francois Santucci (santucci@lotus.univ-corse.fr.) has established the technical group, Modeling and Simulation of Complex Systems, for his research into VHDL. The group has been active in VHDL for over a decade, and has recently proposed using software test schemes in VHDL modeling. Specifically, Prof. Santucci hopes to adapt modern paradigms currently used in software test-module generation and apply those to a VHDL model. If successful, this will allow generation of test data within VHDL code – a significant advance in VHDL modeling. Associate Professors Dr. P. Bisgambiglia and Dr. D. Federici are currently working on a VHDL Behavioral Fault Simulation – a key element of the proposal.

Dr. Martin Stickley
Lasers, Optics and Materials

WOS Report of Dr. Valentin I. Vlad: At AFRL/SNHX, Hanscom AFB, MA, Dr. Chuck

Woods organized perfectly my seminar, many interesting visits and discussions. The seminar took place in SNH conference room, the 22nd Sep. 99. My presentation on "Real-time holographic in photorefractive BTO crystals using optical phase conjugation with a low power laser diode" was followed by a lot of discussions. In the Electro-Optics Lab, I visited a number experiments on optical correlators, spatial modulators, photorefractive crystal growth and characterization and again, the discussions with the American colleagues were very interesting and useful.

Dr. Chuck Woods also organized for me visits to Boston University, Harvard and MIT for the entire week 18-25 September. At Boston University, The Photonics Center, I visited Prof. Bahaa Saleh discussing recent problems on optical phase conjugation and quantum optical information processing, Prof. Fred Schubert on blue laser diodes and high power LED and with Prof. B. Goldberg and S. Unlu on quantum optics. At Harvard, I met Prof. Eric Mazur, Gordon McKay Lab and we discussed ultrashort laser pulsed spectroscopy and waveguide production. At MIT, I visited Prof. Steven Benton and the Media Lab, with the holographic 3D display and movies. By courtesy of my former colleague, Alex Marin from Harvard, HEP Dept, I visited also LIGO experiments in MIT.

My WOS visit included my participation at the Optical Society of America Annual Meeting, Santa Clara, Sept. 26- Oct.2. At this meeting of excellence in optics, I met with joy a large number of American colleagues and friends (some of them after a long time, due to my small mobility dictated by financial situation in my institute and in Romania). I presented the paper "Three-dimensional optical beam propagation and solitary waves in photorefractive crystals with strong optical activity" (co-authors: V. Babin, M. Bertolotti, E. Fazio and M. Zitelli, Paper ThCC7). I had the chance to hear Prof. E. Wolf (who signed in 1978 my OSA Fellow diploma) present two papers. It was very nice to meet him again after many years. At the OSA meeting, I met again Prof. J. Horner, J. Khoury and P. Gianino from AFRL and I followed their very interesting talks. The plenary sessions offered exceptional talks and reviews presented by H. J. Kimble on quantum optics, S. E. Harris on electromagnetically-induced transparency and J. R. Carruthers on photonics in microelectronics industry. The vote for a possible unification between OSA and SPIE was also of great importance for me, as I am a member of both societies since long time (actually, I was also a co-founder of SPIE Romanian Chapter and a vice president of this chapter, in 1991).

Moreover, OSA organized also excellent visits to Stanford University (EE, Ginzton and Chemistry Labs), Lawrence Berkeley National Laboratory (Advanced Light Source) and the laser firm Coherent, Inc. All these visits gave another dimension to my views on the modern optics and many possibilities to speak with the top US scientists working there. The participation in OSA Annual Meeting was equally fascinating by the variety of topics, the outstanding optics scientists giving talks on the hottest problems in optics, the tours at Stanford University, Berkeley National Lab and Coherent. The main book companies displayed at the conference a large number of splendid volumes. Several optical companies showed the newest components and laser systems.

The WOS visit was of exceptional importance for me and I hope that it left a good impression to my host scientists in USA. Many of them accepted to visit our laboratories in Romania and to participate in the next international conference "ROMOPTO 2000", to be held in Bucharest, in September 2000. Many of them accepted also to participate in some common projects. For all these reasons, for the good funding and travel arrangements of this WOS visit, I express all my gratitude to the European Office of Aerospace Research and Development, particularly to Prof. Dr. Martin Stickley and to Stephanie Brewis (Dip.TS).

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Conference: Multiphoton and Light-Driven Multielectron Processes in Organics: Materials, Phenomena, and Applications; Menton, France; 26-31 August 99. The primary host and POC was Dr. Francois Kajzar of DEIN/SPE/GCO, CEW Saclay. 43 scientists from 18 countries participated in this meeting, with the French, the US and Poland leading in attendance. The meeting was a forum for intense discussions and interactions between scientists active in the field of photoactive organic materials. The three meeting themes were: multiphoton absorption, photochromics, and organic electroluminescence. The conference participants wrote brief reports summarizing key observations and conclusions for each of these technical areas. With permission from the conference chairman, Dr. Francois Kajzar of CE Saclay in France, I am reproducing excerpts from these reports for review by the reader:

Multiphoton Absorption: Science and Applications. (George Stegeman, CREOL, U. of Central Florida, was the leader of this group). The field of multiphoton absorption (MPA) in organic materials is not new. It was predicted in the 1930s by Maria Goeppert-Mayer and experiments date back to the 1960s. Multiphoton absorption refers to the absorption of two or more photons from a single laser pulse. This process can either occur through simultaneous or sequential absorption of multiple photons. The first case, the simultaneous absorption of a pair of photons is called two photon absorption (TPA). On the molecular level, it is given by the imaginary part of the second hyperpolarizability $\gamma^{(3)}(\omega)$ and at the condensed matter level as $\Im\mathrm{mag}\{\chi^{(3)}(\omega)\}$ which translates into an increase in the absorption coefficient $\Delta\alpha = \alpha_2 I$ where I is the local irradiance. This phenomenon is the first enabling step to many applications, such as data storage, optical limiting, two photon confocal microscopy, etc. However, TPA has also been viewed as a detriment to all-optical signal processing applications because the key parameter, the nonlinear change in refractive index $\Delta n = n_2 I$ is proportional to the real part of $\chi^{(3)}(\omega)$ and scales the same way with irradiance as the increased absorption. It is primarily in the last decade that the applications of TPA have appeared sufficiently attractive to stimulate researchers to make sustained efforts to study the mechanisms responsible for two photon absorption at the molecular level and develop device technologies.

Higher order MPA such as the simultaneous absorption of three, four or more photons is a consequence of higher order nonlinearities $\chi^{(5)}(\omega)$, $\chi^{(7)}(\omega)$ etc. and has been known in principle from the earliest days of nonlinear optics. However, such effects have been recently shown to be strong in organic media, specifically polydiacetylenes.

The occurrence of two sequential linear absorption events within a single laser pulse relies on generating an initial population in an excited state via the first absorption event. This is followed by the absorption of a second photon raising the molecule either from this excited state, or one coupled to it by a fast transition (relative to the pulse width) to another excited state. This excited state absorption (ESA) frequently exhibits a large linear absorption coefficient between the two excited states. This phenomenon is particularly interesting in large, multiatom organic molecules that exhibit ESA significantly larger than ground state absorption. The overall effect is called reverse saturable absorption (RSA) and the net cross-section scales with increasing fluence (versus irradiance for TPA). Since it clearly depends on population effects, the efficiency depends on multiple parameters such as the linear absorption coefficients involved, the pulse width, the relaxation time between the states involved, etc. It can also be initiated by TPA, appearing as a $\chi^{(5)}(\omega)$ effect, or can occur due to the sequential absorption of more than two photons. RSA is also a first step towards many applications such as optical limiting etc., having many applications in common with two photon absorption.

This overview of the state-of-the-art in MPA is divided into four subject areas: materials, modeling, characterization and applications.

Materials: Although ultimately the specific application and the availability of inexpensive lasers at specific wavelengths will drive the spectral requirements for MPA, the structure-property relations needed to optimize MPA at certain wavelengths, or to achieve broadband spectral coverage are insufficiently understood at present. The work leading into the early 1990s was basically a survey of multi-photon absorption in existing materials. The focus in the last few years has been to understand the mechanisms that lead to large effects, both for TPA and ESA.

The most recent work, primarily in TPA, has been characterized by a search for structure-property relations that will allow new materials to be molecularly engineered. To this end, some specific classes of molecules have been investigated and systematic changes introduced to enhance the two photon cross-sections by factors of up to 100. Some of the largest TPA cross-sections reported to date have been obtained with conjugated systems in linear molecules such as polyenes and polymers such as polydiacetylenes. Selective attachment of donors and/or acceptors and cooperative enhancement in hyperbranched structures appear to be a promising directions to pursue. This, although a useful start, is just the beginning of the systematic investigations needed into structure-property relations for large two photon cross-sections.

Similar progress is being made in ESA materials where the rich excited state spectrum is an advantage offered by large, multiatom organic molecules. Here metal pthalocyanines and other prophyrins are still being investigated. Fullerenes like C_{60}, C_{70} etc. with their rich electronic spectra have been coupled to other molecules to produce new options for ESA.

In virtually all of the projected applications, for example in two photon confocal microscopy, efficient TPA molecules are chemically attached to, or dissolved in, a host medium and the signal levels achieved depend on the local concentration of the TPA-active molecules. Thus the effect of the local environment on the MPA process, i.e. condensed matter effects, are important. Large concentrations of chromophores also raise solubility, aggregation and (photo-) toxicity (when dealing with living tissue) issues. When just maximum nonlinear absorption is needed, single crystal fabrication may be needed. Clearly, all of these issues are important and need to be investigated in the near future.

Characterization: The ability to unambiguously measure the TPA coefficients and all of the linear absorption cross-sections and relaxation times contributing to ESA is important to progress in MPA and its applications.

The two principal TPA measurement techniques fall into two categories: (i) nonlinear transmission and Z-scan which can give a direct measure of the TPA coefficient; and (ii) two photon induced fluorescence which also relies on knowledge of the quantum efficiency of the fluorescence. There have been differences between values deduced from these two techniques, primarily because each has its limitations, implicit assumptions, approximations and competing processes that can affect the final result. (Experimental simplicity is very helpful for screening large classes of molecules.) Very useful to the field would be direct comparisons between measurements by these two techniques on a selective set of molecules, and measurements in different laboratories on the same molecules to better understand systematic sources of error.

For MPA in general, measurements of coefficients at single wavelengths are of limited value. Typically it is the maximum value which is of interest. This requires measurement of the spectral dispersion in the TPA or ESA coefficient and these peak values, their spectral bandwidth and location are of primary interest. In response to these requirements, new nonlinear transmission techniques have been developed using a fixed wavelength as the pump and "white light" continua as a probe. This leads to a direct measurement of the non-degenerate TPA coefficient over large wavelength ranges, i.e. that of the continuum, which now makes rapid characterization of materials feasible.

There is a trend towards using femtosecond excitation for TPA measurements because it can separate, almost unambiguously, the effects due to TPA and ESA. It is now widely recognized that the shorter the pulse width, the smaller population due to linear absorption and the weaker the influence of ESA on TPA measurements. Pump probe measurements with time delayed probes, also with short pulse fast lasers, are becoming more accepted for ESA studies and the quality of the data obtained now allows discrimination between different multi-path processes, the number of states involved and the identification of the key inter-state relaxation rates.

Modeling: Modeling of multi-photon effects, most specifically TPA, has been getting progressively more sophisticated. There are three current approaches being used: (1) a perturbative theory derived sum over states which has been well established for second order nonlinearities; (2) a new "residue" analysis of the response function approach which appears to be having initial success when compared to experiments and; (3) the density matrix theory based on anharmonic oscillators. Although each approach has had some progress in MPA predictions, they each have their respective strengths and weaknesses (approximations). In general, the most progress has been made in predicting trends in a class of related molecules, but absolute values are still a problem for the large molecules that give useful TPA coefficients.

An important milestone would be a critical comparison between the predictions of different theoretical approaches, and their comparison with experiments from a number of different laboratories on the same molecules.

The first two techniques are limited to single molecules, and classical local field effects etc. at the Onsager and Lorentz level are employed to describe condensed matter systems. This can be a problem since local fields can be very large for third order nonlinear processes such as TPA. Thus far, only the density functional approach attempts to handle condensed media in a systematic way.

In terms of RSA, theoretical progress has been slow, especially in condensed matter systems. Broadband ESA, for example as needed in optical limiting, requires a spectrally broad excited state spectrum, which in turn implies large molecules: And large molecules are difficult to model. Here it is hoped that the "residue" analysis of response functions will make a contribution.

Applications: Many of the applications of MPA being currently pursued were proposed at least a decade ago. It is only with focused efforts on generating more efficient MPA materials that some have approached practical realization. As mentioned previously, MPA is usually the enabling, first process needed. The applications are based on diverse effects such as two photon fluorescence, two photon activated chemical processes such as polymerization or structural conformations such as cis-trans isomerization, two or more photon-initiated changes in optical properties such as absorption and refractive index, flux dependent excited state absorption etc.

ESA has been one of the key processes for optical limiting devices for a number of years now. State-of-the-art limiters now consist of multiple stages in tandem in a tight focus geometry, even with the possibility of different materials in each stage.

A number of applications rely on the increased local irradiance available in the focal region of a microscope. As a result efficient MPA only occurs in this focal region optically localized to volumes of a few cubic optical wavelengths, i.e. to micrometer dimensions. For example, two photon induced polymerization or cross-linking has enabled various three-dimensional structures to be fabricated including MEMS devices, optical waveguides, photonic band gap structures, etc. Another example is the application to biophysics of two photon fluorescence imaging with “tag” molecules processes locally both on cellular and tissue levels. Yet another example is in digital (on-off) data storage where local chemical reactions, cis-trans conformational changes etc. can be triggered by two photon absorption. These applications are in various stages of commercialization with the most advanced being the two photon confocal microscope which is already a commercial product.

<u>*Photochromism*</u>: (Roger Lessard, COPL, Laval University, Quebec was the leader of this group.) This workshop was intended to discuss problems related to photochromism, its application, and how to choose or design the best possible molecules. First, however, a broad discussion was held on the meaning of photochromism, and the following definition was agreed upon: 'Photochromism is a reversible photo-induced chemical process in which at least the primary step must be driven by light radiation'. This definition is much larger than the normally accepted definition of photochromism, which many researchers restrict to only color changing chemical systems under illumination.

The development of materials with light-controlled properties is driven by many applications ranging from optical data storage and processing to the protection against intense laser pulses in optical limitation. Photochromic molecules offer in principle the possibility to meet material requirements for these applications, but require optimization and adjustment of their properties: spectral properties, speed of their response, and reversibility and stability as well as fatigue resistance, all of which depend on temperature and the environment.

To fulfill this task, new photochromic molecules must be designed for stability and for a given wavelength of irradiation, and the final product must be in a solid phase, the final price must be affordable, and the final solid phase product must exhibit very good optical quality. The molecules used can be ones such as spiropyran, spirooxazine, fulgide, and diarylethene, which belong to the color change class, or azobenzene molecules. One of the participants mentioned the use of hypervalent molecules as one of the possible avenues for using photochromism in many applications. All classes of molecules can be used for doping polymer matrices or can be attached or grafted onto polymer main chains.

Besides photochromic compounds, which undergo a photochemical reaction at a molecular level, there exists some molecular materials where the relaxation of photoexcited states result in drastic structural changes involving a large number of electrons and molecules. These cooperative phenomena are carried to an extreme in the case of photoinduced phase transformations, i.e. where light triggers a macroscopic phase transformation ('from self-trapping to phase transition'). This change in molecular identity is manifested by a change of color, as well as by the appearance of new dielectric, magnetic, or conducting properties. Examples are: (i)spin-crossover transitions (low-to-high spin state), (ii) valence instability in mixed-valence mx chains, (iii) inverse spin-peierls transitions, and (iv) neutral-ionic transitions (multi-electron transfer). Some photoinduced phase transformations also exist in some inorganic materials as oxides (manganite in particular) All systems must show a suitable reaction rate, a good quantum efficiency, and a good photochemical efficiency.

Organic Electroluminescence: (Vladimir Agranovich, Institute of Spectroscopy, RAS, Moscow was the leader of this group.) The workshop participants met on three occasions to discuss the general problems of the science of organic electroluminescence and the technology of organic light-emitting devices. Two general questions were formulated and attempted to be answered on the basis of the conference papers as well as the knowledge and experience of the group members.

The questions were: 1) Is the electroluminescence (EL) a phenomenon one that can bring new insight into basic physical phenomena in organic molecular aggregates? and 2) Is the present knowledge and experience in EL sufficient to tailor and to produce commercially available organic EL devices?

On the first question, all of the group members agreed that studying EL phenomena can provide new and important information on many electronic processes and on the structure of organic molecular aggregates. Among the phenomena of particular interest are: (i) carrier injection mechanisms at organic/organic and organic/inorganic interfaces, (ii) charge carrier recombination including large organic molecules, (iii) electric field effects on molecular electronic states and their excitation mechanisms including, in particular, the nature of excited states produced in the electron-hole recombination process, (iv) charge carrier transport mechanisms with emphasis on the carrier motion at high electric fields, (v) kinetics of polaritons and excitons in EL cavity systems, and (vi) the intermolecular structure as observed by recombination EL when utilizing surface-tunnelling-microscopy.

On question 2, there was no general agreement despite positive opinions, i.e. present knowledge is close / very promising for the manufacture of commercial EL devices. Several conditions were formulated for organic EL devices to be tailored to meet various performance parameters (color, quantum yield, brightness, driving current and voltage, durability, chemical resistance): (i) establishment of a relation between the interface structure and injection mechanisms of charge carriers, (ii) development of a theoretical description of electric field effects on various parameters responsible for performance of EL devices (existing observations of such effects are not well understood), and (iii) coming to grips with the deterioration mechanisms of EL devices based on different organic solids.

Specific topics discussed in detail during the group meetings include (i) types of organic EL : why does recombination EL attracts researchers the most ? (ii) thin film versus single crystal EL: differences and similarities, (iii) low molecular-weight materials and polymers: do they show fundamental differences in characteristics of EL devices?, and (iv) materials versus device structure: how do they influence the EL phenomena?

The Conference showed that a broad spectrum of EL topics were of interest to physicists, chemists and engineers. It was concluded that organic electroluminescence is a strongly emerging field of molecular science, and is a phenomenon full of photophysical and photochemical processes, each having fundamental and technological importance.

Conference: Nonlinear Optical Materials Workshop, DERA, Great Malvern, England; **20-21 September 99**. The primary host and POC was Dr. Tony Vere. 41 scientists attended this meeting including 11 from the US (5 from WPAFB), 6 from Russia, and the balance from the UK (mostly DERA). The focus of the meeting was on the science and technology of growth and characterization of chalcopyrite materials, particularly zinc-germanium-phosphide (ZGP) and cadmium-germanium-arsenide (CGA), that have the promise of enabling high power, tunable sources in the mid- and far-infrared (3 to 18 microns) when pumped by high irradiance, repetitively pulsed, single wavelength lasers. Attention was also paid to progress and problems in alternative materials and quasi-phase matching technologies (periodically-poled lithium niobate [PPLN] and potassium-titanium-phosphide [KTP] and their analogs) for mid-IR sources).

The principal problem with ZGP is excess absorption in the two-micron range leading to undesired pump light absorption and heating of the material. The generally accepted goal is to reduce this to <0.1 cm^{-1}. How to do this seems to depend to a considerable degree on where the material is being grown: Lockheed-Martin (Sanders) (peter.g.schunemann@lmco.com) in the US, DERA in the UK (cjflynn@dera.gov.uk), or ATOM in Tomsk (voevodin@elefot.tsu.ru) . The origin of the absorption is not clear, but probably a number of factors are important, including scatter by microinclusions (Voevodine) in the crystals. High temperature annealing is generally an important approach to lowering the residual absorption, but it is not the complete answer. Absorption losses of ~0.05 cm^{-1} are achieved by LM/Sanders (Schunemann). Others report values that are factors of 2 to 3 higher. Verozubova of the Institute of Optical Monitoring in Tomsk (galina@losiom.tomsk.ru) reported absorption losses of 0.01 cm^{-1} achieved by electron irradiation. More work needs to be done to understand the origin of this undesired loss. Crystals can be grown over some weeks that are the size of one's thumb; these are considered satisfactory for most applications.

CGA is a prime candidate for doubling CO_2 lasers into the 4-5 micron region but it still suffers from excess absorption of ~0.2 to 0.4 cm^{-1} in the 4 to 12 micron range. Current efficiencies of 28% at 273K and 53% at 77K are achieved for doubling CO_2 radiation (Schunemann).

Several presenters discussed periodic poling. While PPLN is a low cost material, it still suffers photorefractive damage (but this can be annealed out if the sample is operated at a sufficiently high temperature), it causes beam divergence problems, and it has a small input aperture that limits power output. An effort to achieve quasi-phase matching with GaAs for doubling CO_2 radiation has not worked due to the great technological problems that come with trying to fabricate, AR-coat, and then squeeze together 100 wafers of GaAs each three coherence lengths thick (shekar.ghua@afrl.af.mil).

In the category on new materials: (a) Fernelius (nils.fernelius@ml.afrl.af.mil) reported that the Rockwell Science Center (with AFRL support) has disclosed a new class of nonlinear materials that includes Tl_3PbBr_5, and K_2ZnCl_4; these compounds have been grown by the Bridgman method in large sizes and useful shapes and Schunemann reported the development; (b) Dy^{3+}:$CaGa_2S_4$ that lases at 300K at 4.4 microns and can be pumped by the 1.3 micron transition in Nd:YAG (this was done in conjunction with S. Payne of LLNL); and (c) periodically poled $BaTiO_3$. This material offers a longer IR cut-off wavelength enabling full coverage of the 3-5 micron region, a low coercive field (200x lower) and a larger aperture than PPLN, and a large nonlinear coefficient, d_{15}=17pm/V. It was used to double 10W of 2.05 microns to produce 345 mW at 1.025 microns. It was operated at 55C and showed no evidence of photorefractive damage or thermal lensing.

Dr. Roy Phillips
Policy and Strategy

Meeting Attendance: ISTC Governing Board, Moscow, Russia, 26-27 October 99. The International Science and Technology Center (ISTC) is a multilateral organization created to provide weapons scientists in Russia ,and other former Soviet Union countries with opportunities to re-direct their talents to peaceful purposes. The ISTC's Secretariat is located in Moscow.

Earlier this year EOARD was granted Partner status with the ISTC. This provides EOARD with the ability to fund research in Russia through the ISTC. Advantages to funding projects through the EOARD Partnership with the ISTC include:

- Exemption from all taxes on payments to project scientists;
- Exemption from all customs duties on imports in connection with the project;
- Direct payments to project scientists in US dollars;
- Financial control and regular audits, in compliance with GAAP; and
- Pre-approval of and support for the project by the host government.

This meeting provided an opportunity to coordinate our relationship with the ISTC through interaction with ISTC staff and the US delegation to the Governing Board. The first three EOARD Partner projects were approved with a November 1, 1999 commencement date.

Meeting: STCU Secretariat, Kiev, Ukraine, 28 October 99. The Science and Technology Center in Ukraine (STCU) is a sister organization of the ISTC centered in Kiev. It offers similar advantages to its Partners and EOARD is in the process of establishing a Partnership arrangement with the STCU.

Major Tim Lawrence
Space Technology

Conference: Kick-off meeting and Stationary Plasma Thruster seminar, AFRL/PR, Edwards AFB CA, 29 September - 2 October 99. The primary host and POC was Dr. Ron Spores. I accompanied Dr. Vladimir Kim and Dr. Boris Arkipov of Fakel for a meeting at Edwards AFB to discuss low power stationary plasma thruster (SPT) work in Russia. This meeting also served as a kick-off meeting for the EOARD contract to develop a 100-watt SPT for testing at Edwards AFB.

Dr. Ron Spores started off the meeting by briefing the current status of spacecraft propulsion at AFRL. Dr. Mike Fife then presented the current research into SPT thrusters at AFRL. Dr. Kim then gave a presentation on the design issues of small, low-power SPT's. Magnetic field intensity and mass flow rate are the key parameters in the design. Dr. Boris Arkipov presented his work at Fakel on faster start up cathodes. The group toured the facility and discussed integration requirements for testing the thruster at AFRL.

The meeting was viewed as being very fruitful for all parties. Dr. Spores challenged Fakel to design a thruster that can achieve high efficiency and overcome the design hurdles presented by Dr. Kim. Fakel will start the contract on 1 November.

Conference: International Astronautics Federation, Amsterdam, Netherlands, 3 – 9 October 99. Major Jerry Sellers also attended this conference; please see his comments for a general overview of the conference.

I presented the paper "International Collaboration in Electric Propulsion," with Dr. David Fern of DERA, UK on international collaboration in electric propulsion. Please contact me to obtain a copy of this paper.

I also gave an update on the NASA Glen Breakthrough Propulsion Program for Dr. Marc Millis, who could not come to the conference. This presentation generated extreme interest among the European participants since they were not aware of NASA and US interest in advanced propulsion. This could lead to future collaboration with Star Labs Belgium and Russian institutes. We may also sponsor a seminar for all interested European parties if there is enough interest.

Site Visit: Contractor meeting with Tsniimash and Izmiran, Korolev, Russia, 10 – 15 October 99. The primary host and POC was Alexander Semenkin. I attended this meeting with Major Jerry Sellers. Please see his Eurogram report for details of the entire visit.

My specific meetings focused on electric propulsion. I spent two days at Tsniimash observing test results of their D38 and D27 Thrusted Anode Layer (TAL) thrusters. This work was in support of an EOARD-administered contract. Dr. Ron Spores, AFRL/PR, is the sponsor. Tsniimash has a very thorough understanding of electric propulsion. They began their research activities in 1962 and have focused their research on stationary plasma thrusters and magneto-plasma dynamic thrusters (MPD's). They tested a 25 kW Bismuth TAL thruster in the 70's for interplanetary type missions. Their current research is looking at low- to medium-class TAL thrusters for NASA and Teledesic type missions.

I was impressed with theTsniimash test facilities and test approach. They have many redundant systems to insure accurate measurements of thruster performance. They tested at various power levels and received efficiencies of 38%, 24%, and 11% at power levels of 150, 125, and 100 W respectively for the D27 thruster. They will continue tests in support of the contract, and vary the mass flow rate, magnetic field strength, and thruster power to determine the optimum conditions for low power operation and present design issues for future development.

I also visited with Dr. Vladimir Kim of the Fakel Design Bureau to discuss the status of their low power SPT development contract and tour his facilities. Dr. Kim fired the SPT-20 thruster @ 100 W input power and also discussed their goal of varying input power, magnetic field strength, and mass flow rate to determine the optimum configuration for 100 W of operation. Dr. Kim also presented work on pulsed plasma thrusters which showed test data of 100 W input power producing 2.5 mN thrust and 120 W producing 4.5 mN thrust. The total thruster weighs 5 – 7 kg in the flight configuration.

Dr. Ilia M. Chertok of Izmiran presented his recent research into observations of x-ray chains on the sun in periods of high solar activities. This is the first time this phenomena has been observed. He delivered a report with all of the technical details. Please contact me if you are interested.

Site Visit: DERA, Farnborough, United Kingdom, 26 October 99. The primary host and POC was Dr. Dave Fern. I first met with Commander Richard Blott who gave a tour of the Satellite Test & Research Vehicle (STRV) C and D spacecraft. These 100-kg spacecraft are to be launched on the Ariane V in the spring of next year, carrying BMDO, AFRL, NRL, SMC, and NASA payloads. Please contact me for the specific details of these payloads.

I toured the ion propulsion laboratory with Dr. Dave Fern. Dr. Fern showed the T-6 thruster in operation. They are in the performance characterization phase, with a goal of 150 mN at 5-kW input power, and plan to start lifetime tests soon under the sponsorship of the British National Space Centre. They are also working on a cathode for a 5-kW Hall thruster being developed by Keldysh and Matra Marconi Space.

Recent results of this work is summarized in "Low Cost Orbit Maneuvers for Minisatellites Using Novel Resistojet Thrusters" by M. Sweeting, T. Lawrence, and J. Leduc. This paper was published in the November 1999 volume of the J. Inst. Mechanical Engineers, UK.

Captain Tony Mitchell, University of Paris
Laser Workshop

Captain Tony Mitchell is a former ESEP exchange engineer currently completing Ph.D.

studies at the University of Paris. He is slated to join the faculty of Aeronautics at the US Air Force Academy in summer 2000. He contributes to the Eurogram as an "adjunct program manager" from time to time.

Workshop on Laser Doppler Velocimetry, St. Pierre D'Oléron, France, 19-24 Sep 1999

This biannual workshop was sponsored by the Francophone Laser Doppler Velocimetry Association (AFVL). The AFVL provides its French-speaking members with courses, symposiums, and conferences dealing with various laser based measurement techniques (www.lcd.ensma.fr/afvl). The workshop was held at the French National Scientific Research Organization (CNRS) facility on the Island of Oléron and was attended by fifty scientists, engineers and doctoral candidates.

Based on the two measurement methods of Laser Doppler Velocimetry (LDV) and Particle Image Velocimetry (PIV), the primary goal of the workshop was to provide the theory and techniques necessary to effectively utilize these methods. A second objective was to provide insight and details on state-of-the-art advances to those researchers who already implement these experimental methods. In addition to the academic sessions and round-table discussions, a number of different vendors presented demonstrations of their hardware and software systems.

The workshop material included an introduction to LDV and PIV (theory and experimental techniques), measurement methods for single and multi-components of velocity, various flow seeding methods and associated problems, data and signal analysis, bias and statistical errors, post-processing of the results and recent developments. Two PIV-specific sessions discussed various methods of image acquisition and the correlation of these images. In addition to these two principle topics, the workshop also examined the optical physics associated with the diffusion and diffraction of light around seeding particles, "Granulometry", which is essential for a better understanding and interpretation of experimental results. To supplement the theoretical aspects of each of the respective topics, a number of applications related to subsonic, transonic and supersonic aerodynamics as well as combustion and detonation physics were presented.

The following is a list of experts who presented material throughout the workshop. Dr. Alain Boutier (ONERA, Châtillon, France) is the Director of Research at ONERA and is world-renowned for his work related to LDV systems. Dr. Max Elena (IRPHE, University of the Mediterranean, Marseille, France) is known for his research in LDV. Dr. Jacques Haerting (Institute of St. Louis, France) has accomplished numerous experiments using LDV and is shifting his focus towards PIV for applications in both incompressible and compressible flows. Dr. Pierre Millan (ONERA, Toulouse, France) is Assistant Director of the ONERA's Department of Turbulence and is currently performing research in Doppler Global Velocimetry (DGV), PIV and in Granulometry. Dr. Jean-Michel Most (Combustion and Detonation Lab, ENSMA, Poitiers, France) is primarily involved in using LDV and PIV techniques to analyze combustion. Dr. Michel Reithmuller (Von Karman Institute, Belgium) is world renowned for his research in PIV methods and applications. Dr. Michel Trinite (CORIA, University of Rouen, France) is performing research with various applications of PIV.

Further details on the contents of the workshop, the participants, or those who taught the workshop are available. Please contact Captain Tony Mitchell (mitchell@onera.fr).

CONFERENCE SUPPORT

EOARD promotes technical interchange by supporting and co-sponsoring technical workshops and mini-symposia at overseas conferences. We often receive in return proceedings and attendance for one or more Air Force representatives. Air Force R&D personnel attending or considering attending European conferences should contact EOARD for further information. For further details on the conferences below contact the program manager indicated (see footnotes). **Bi-service and tri-service support efforts are in bold print.**

Dates (1999)	*Location*	*Conference/Workshop Title*	*LO*[1]
1 - 12 Nov 99	Isaac Newton Inst for Math. Sciences, Cambridge,UK	Models of Fracture	RSF
18 - 20 Nov 99	Bad Radkersburg	Assessment of stress intensity and stress compatibility in large groups under construction	BTM
6 - 10 Dec 99	Almaty, Kazakhstan	First International Kazakh-American Conference on Information and Control Systems http://www.banknet.kz/kaz-itc/	BTM
6 - 7 Dec 99	**Technion, Haifa, Israel**	**IMEC-9 : The 9th Israel Materials Engineering Conference www.technion.ac.il/technion/materials**	**JJS/ RSF**
27 - 29 Sep 00	Amsterdam	How eye movements serve the needs of vision in the natural world	BTM

[1] BTM-Barry T. McKinney; CMS-Martin Stickley; CNR-Charbel N. Raffoul; JAH-Jay A. Howland; JJS-Jerry J. Sellers; RSF- Robert S. Fredell;TL-Tim Lawrence

WINDOW ON SCIENCE

EOARD initiates and promotes technical liaison between Air Force and foreign scientists very effectively with the Window On Science (WOS) program, through which we can arrange and fund visits of foreign scientists to selected Air Force facilities. To nominate a WOS candidate, contact your Technical Director or your EOARD discipline representative. WOS visitors currently on contract are listed below. For further details contact the program manager indicated (see footnotes). **Bi-service and tri-service coordinated visits are in bold print.**

Dates (1999)	*Traveler*	*Country*	*Topic*	*Location(s) of US Visit*[1]	*LO*[2]
28 Oct - 9 Nov 99	Dr. Valentin Bityurin	Russia	Plasma Aerodynamics	NASA GRC	PJO
28 Oct - 9 Nov 99	Dr. Anatoli Klimov	Russia	Plasma Aerodynamics	NASA GRC	PJO
28 Oct - 9 Nov 99	Dr. Serguei Leonov	Russia	Plasma Aerodynamics	NASA GRC	PJO
30 Oct - 6 Nov 99	Dr. Serguei Kostromin	Russia	Hypersonic Systems	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr. Valery V. Lazarev	Russia	Hypersonic Systems	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr. Nikolai Dembo	Russia	Hypersonic Systems; Aeroengines	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr. Vitali Smoliarov	Russia	Hypersonic Systems	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr. Kirill Khodataev	Russia	Hypersonic Systems	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr. Igor Timofeev	Russia	Hypersonic Systems	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr. Artur Krasilnikov	Russia	Hypersonic Systems	Norfolk, VA	CNR
30 Oct - 6 Nov 99	**Dr. Alexei Korabelnikov**	**Russia**	**Plasma Aerodynamics**	**Norfolk, VA**	**CNR**
30 Oct - 6 Nov 99	Dr. Alexandre Lanshin	Russia	Hypersonic System	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr. Alexander Kuranov	Russia	Hypersonic System	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr. Vladimir Sosunov	Russia	Hypersonic Systems	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr. Nicolay Anfimov	Russia	Hypersonic Systems	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr. Gorimir Chernyi	Russia	Hypersonic Systems	Norfolk, VA	CNR
30 Oct - 6 Nov 99	**Dr. Evgueni Cheikine**	**Russia**	**Hypersonic System**	**Norfolk, VA**	**CNR**
30 Oct - 6 Nov 99	Dr. Vladimir Levin	Russia	Hypersonic Systems	Norfolk, VA	CNR

Dates (1999)	Traveler	Country	Topic	Location(s) of US Visit[1]	LO[2]
30 Oct - 6 Nov 99	Dr. Valeri Chibkov	Russia	Plasma Physics	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr Serguei N. Tchouvachev	Russia	Weakly Ionized Plasma	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr. Alexei Erchov	Russia	Hypersonic Systems; Aeroengines	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr. Vitalii V. Kislykh	Russia	Hypersonic Systems	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr. Anatoly F Kolesnikov	Russia	Hypersonic Systems	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr. Alexandre Kraiko	Russia	Hypersonic Systems	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Prof. Andrey F Aleksandrov	Russia	Hypersonic Systems	Norfolk, VA	CNR
30 Oct - 6 Nov 99	Dr Alexander V Rodionov	Russia	Rocket plume modelling	AEDC, Tullahoma, TN	JJS
30 Oct - 6 Nov 99	Dr Boris A Khmelinin	Russia	Rocket plume modelling	AEDC, Tullahoma, TN	JJS
30 Oct - 6 Nov 99	Mrs Galina G Baula	Russia	Rocket plume modelling	AEDC, Tullahoma, TN	JJS
30 Oct - 6 Nov 99	Mr. Carlos Gonzalez	Spain	Fatigue of metal matrix composites	AFRL/MLL	RSF
30 Oct - 6 Nov 99	Professor Javier Llorca	Spain	Fatigue of metal matrix composites	AFRL/MLL	RSF
31 Oct - 10 Nov 99	Dr. Boris Malomed	Israel	Optical soliton propagation	AFRL/DELO, Kirtland AFB, NM, and San Francisco, CA	CMS
6 - 10 Nov 99	Mr. Malcolm Paul	United Kingdom	Hydrogen peroxide propellant research	Purdue University, West Lafayette, IN	JJS
6 - 10 Nov 99	Mr. Vadim A Zakirov	United Kingdom	Hydrogen peroxide propellant research	Purdue University, West Lafayette, IN	JJS
6 - 10 Nov 99	Mr. Richard Brown	United Kingdom	Hydrogen peroxide propellant research	Purdue University, West Lafayette, IN	JJS
6 - 10 Nov 99	Dr. John Harlow	United Kingdom	Hydrogen peroxide propellant research	Purdue University, West Lafayette, IN	JJS
7 - 14 Nov 99	Prof. Sergei Pyshkin	Moldova	Materials science	5th Int Conf on Display Phosphors, 8-10 Nov 1999, San Diego, CA:	BTM
13 - 19 Nov 99	Prof. Zvonimir Sipus	Croatia	Antenna measurements	HRS	BTM
18 - 20 Nov 99	Dr. James Whitelaw	United Kingdom	Active combustion control, PDE	NASA GRC	PJO
27 Nov - 2 Dec 99	Dr. Galina Verozoubova	Russia	Composition and spectroscopy of ZnGeP	AFRL/SNHX, Hanscom AFB, MA and MRS Meeting, Boston, MA	CMS
27 Nov - 2 Dec 99	Dr. Alexander Gribenioukov	Russia	Preparation of zinc-germanium-phosphide	AFRL/SNHX, Hanscom AFB, MA., and MRS Meeting, Boston, MA	CMS
22 Nov - 3 Dec 99	Dr. Ad Vlot	Netherlands	Repair of fatigue-damaged aircraft structures	USAF Academy, USAF Aircraft Structural Integrity Conference, San Antonio TX	RSF
27 Nov - 3 Dec 99	Prof Jacobus Schijve	Netherlands	Fatigue of aircraft structures	USAF Aircraft Structural Integrity Conference, San Antonio TX	RSF
27 Nov - 3 Dec 99	Mr Dan Lindahl	Sweden	Acoustic emission monitoring of acft structures	USAF Aircraft Structural Integrity Conference, San Antonio TX	RSF
6 - 11 Dec 99	Prof Vladyslav Mazur	Ukraine	Titanium eutectic composites	AFRL/MLLM, Wright-Patterson AFB OH	RSF
6 - 11 Dec 99	Prof. Sergey Firstov	Ukraine	Titanium eutectic composites	AFRL/MLLM, Wright-Patterson AFB OH	RSF
6 - 12 Dec 99	Dr. Vladimir Gorodetski	Russia	Controls, Information Technology	First International Kazakh-American Conference on Information and Control Systems	BTM
11 - 17 Dec 99	Dr. Pierre Andre Rene Marie Laroche	France	Triggered lightning	State Univeristy of New York, Albany, NY; American Geophysical Union Annual Meeting, San Fransciso, CA	JJS
8 - 14 Jan 00	**Dr. Ismet Gursul**	**United Kingdom**	**Fin buffeting**	**AIAA-Reno Hilton**	**CNR**
9 - 22 Jan 00	**Dr Vincent G Couaillier**	**France**	**Computational fluid dynamics**	**AIAA-Reno; AFRL/Dayton, NASA Glenn**	**CNR**

[1] AFRL Research Sites–**ARS**: Armstrong Research Site, Brooks AFB, TX; **ERS**, Edwards Research Site, Edwards AFB, CA **HRS**: Hanscom Research Site, Hanscom AFB, MA; **PRS**: Philips Research Site, Kirtland AFB, NM; **RRS**, Rome Research Site, Rome, NY; **WRS**: Wright Research Site, Wright-Patterson AFB, OH; Other sites: **AEDC**: Arnold Engineering Development Center, Arnold AFB, TN; **USAFA**: Air Force Academy, Colorado Springs, CO; **ARL**: Army Research Laboratory

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